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BULLETIN NO. 21, NEW SERIES.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.

PRELIMINARY REPORT

ON THE

INSECT ENEMIES OF FORESTS IN THE NORTHWEST.

AN ACCOUNT OF THE RESULTS GAINED FROM A RECONNAISSANCE TRIP MADE IN THE SPRING AND EARLY SUMMER OF 1899.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST

A. D. HOPKINS, Ph. D.,
Vice-Director and Entomologist of the West Virginia Agricultural Experiment Station.

WASHINGTON:
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1899.

DIVISION OF ENTOMOLOGY.

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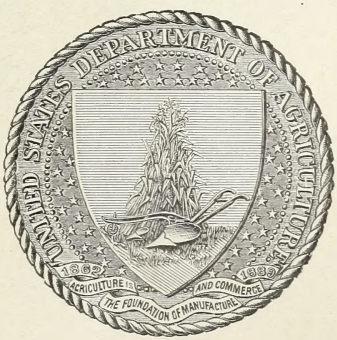

WASHINGTON:

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1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., October 18, 1899.

Sir: I have the honor to transmit herewith manuscript of a preliminary report upon forest conditions as relating to insect work in portions of the States of Oregon, Washington, and Idaho, which has been prepared by Dr. A. D. Hopkins, of the West Virginia Agricultural Experiment Station, and which is based upon observations made by him under commission from this Division during April, May, and June of the present year. Dr. Hopkins was chosen for this work on account of his great knowledge of forest insects, a subject of which he has made a special study for a number of years, his previous observations having been made largely in the State of West Virginia. The writer considers himself fortunate in being able to secure Dr. Hopkins's services for this investigation, and feels sure that the results obtained, even as displayed in this preliminary report, will be of value to the forest interests of the Northwest. The publication of this report as Bulletin No. 21, New Series, is recommended.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

PREFATORY NOTE.

The accompanying preliminary report of my investigations of insects injurious to forests in California, Oregon, Washington, and Idaho is made in accordance with the authorization of the Secretary of Agriculture, dated March 30, and the letter of the Entomologist, dated April 11, 1899.

Before proceeding further, I wish to express grateful acknowledgments to all those who have in any way assisted me in this work, among whom the following deserve special mention: Messrs. Pergande and Busck, for the excellent care of the breeding material sent in from the field; Mr. Hine, for the excellent and rapid manner in which the reared and collected insects were mounted; Mr. Clifton, for assistance along other lines, and especially Mr. Schwarz, who devoted much time outside of office hours in helping me to make the preliminary investigation and classification of alcoholic material and the determination of the Coleoptera.

In addition to the above I should mention my obligations to United States Senator McBride for letters of introduction to persons in Oregon who gave me valuable information.

Among the entomologists and other members of the staff or faculty of the several universities and experiment stations visited whose hospitality and interest in furthering the objects of the journey deserve special mention were Dr. Hilgard and Professors Woodward and Davy, of the University and Experiment Station at Berkeley, Cal.; Professors Cordley and Lake, of the Agricultural College and Experiment Station at Corvallis, Oreg.; Professor Kincaid, of the State University of Washington; Professor Piper, of the Agricultural College of Washington, and Professors Aldrich and Henderson, of the University of Idaho.

A. D. H.

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PRELIMINARY REPORT ON THE INSECT ENEMIES OF FORESTS IN THE NORTHWEST.

OUTLINE OF TRIP, AND LOCALITIES VISITED.

I left Morgantown, W. Va., April 9, and Washington, D. C., April 12, and, going by the southern route through Texas, New Mexico, Arizona, and California, arrived in San Francisco on the evening of April 17. The following day (April 18) was spent in visiting the University of California, at Berkeley, where I called on Professor Woodworth, entomologist, and Prof. J. B. Davy, botanist, of the Agricultural Experiment Station, who offered every facility and gave valuable assistance in my study of the native forest trees represented in the university arboretum. Here I collected numerous species of Scolytids from the pines and other conifers.

On April 19 I proceeded to Guerneville, Cal., some 70 miles north of San Francisco, to investigate the insect enemies of the California redwood (*Sequoia sempervirens*), and, in addition to several other species of insects collected from the bark and wood of this tree, I found that *Phlœosinus cristatus* was a very common enemy.

On April 20 considerable time was spent in Golden Gate Park, San Francisco, studying the indigenous trees of the Pacific coast represented there, and in collecting specimens of insect enemies of the park trees. I also called on Mr. N. Hoffman, who is a dealer in imported and native woods, and is well informed on the timber interests of the Pacific coast, and obtained from him some valuable information.

I left San Francisco to pursue my investigations in the vicinity of McCloud and Sisson, Cal., where I had been informed some timber was dying, and arrived at the former place, a small village in the heart of the yellow and sugar pine forests, on the southern slopes of Mount Shasta, April 21. Among the more important observations made here was the discovery of a bark-beetle of the genus Dendroctonus killing the yellow pine, and another of the genus Scolytus doing great damage to living fir trees. In addition to this a large number of heretofore unrecorded facts were noted regarding the insect enemies of the spruce, fir, cedar, pines, etc. The owners of the timber in this locality expressed themselves as much interested and pleased that these subjects were being investigated, and they kindly offered

every facility for prosecuting the work, furnishing livery, tools, guides, etc.

April 22, I arrived at Grants Pass, Oreg., and investigated the condition of the forests in relation to insect depredations in the mountains north, northeast, and southwest of the city. The most important feature found here was the prevalence of the same species of Dendroctonus discovered at McCloud, and many hundreds of trees which had evidently died from its attack. In one place a group of over thirty trees were dying. These were carefully investigated. The living and dying bark were found to be infested with different stages of the Dendroctonus, and quite conclusive evidence was found that the death of these trees was primarily due to the attack of this bark-beetle. In another section it was found that the same species had attacked the sugar pine, *Pinus lambertiana*, which, with *Pinus ponderosa*, are among the most valuable timber trees of the Northwest. The discovery was also made here that this Dendroctonus was not attracted to felled trees, as is the case with most other Scolytids, but is attracted to, and freely breeds in, trees that have been girdled by the settlers and farmers in the process of clearing the land; and that these trees form nuclei for the multiplication and spread of the pest to the healthy trees in adjoining forests.

Leaving Grants Pass on the 27th, I spent a few hours profitably collecting specimens near Albany and Corvallis, arriving at the latter place in the evening. In accordance with instructions I visited the agricultural college and experiment station here on the 29th, and called on the entomologist, Prof. A. B. Cordley.

The next day, April 30, accompanied by Professor Cordley, I proceeded to Newport, Oreg., at the mouth of Yaquina Bay, where I spent the day investigating the insect enemies of the trees of this most interesting section. Among the important observations made here was my discovery of a Scolytid enemy of the white alder (*Alnus rhombifolia*), which is very common and quite injurious to this tree. Another species of Scolytid, representing an undescribed Hylesinus, was found to be common in the bark of recently felled hemlock. These observations had the added interest of being the first record of Scolytid bark-beetles infesting alder and hemlock. An undescribed Dendroctonus was found in the bark of *Picea sitchensis*, and several other Scolytids, which are undescribed, were found in this spruce and in *Pinus contorta*. I was also fortunate in finding in a cone of the last-named tree Mr. Schwarz's rare and interesting species, *Pityophthorus coniperda*, the occurrence of which on this coast is most remarkable. Taking it all in all, this locality proved to be one of especial scientific and economic interest.

May 1, we returned to Corvallis, and the following day, accompanied by Professor Lake, horticulturist and botanist of the college and sta-

tion, we proceeded into the Cascade Range, stopping at Detroit, near the terminus of the railroad, where two days were spent in profitable observations of the forest conditions and insect enemies of the cedars, firs, spruces, pines, hemlock, maple, etc.

May 4, two guides were secured at Berry, Oreg., and we entered the Cascade Forest Reserve. Here I made some important observations regarding a trouble which had caused the death of large numbers of noble firs (*Abies nobilis*) and hemlock. While I was not able to secure specimens of the insects which doubtless caused the death of these trees (owing to the fact that the trees had been dead too long), I concluded from the character of their work on the outer sapwood that it must be a Buprestid, possibly belonging to the genus Melanophila. Many had healed over before the trees died, thus presenting conclusive evidence that they were attacked while living and probably while in healthy condition.

While on my way to Portland, May 5, I stopped at Salem and called on Mr. E. C. Giltner, to whom I had a letter of introduction from United States Senator McBride. Mr. Giltner was very kind in giving information and in introducing me to persons who were familiar with the forest conditions of certain sections of the State.

May 7, I proceeded to St. Helen, Oreg. Here investigation was made of a serious trouble affecting the hemlock and red fir, which proved to be similar to, if not identical with, that affecting the hemlock and noble fir in the Cascade Reserve, near Berry. The work of a Buprestid larva was found in healthy, dead, and dying trees, and I was fortunate in securing a few larvæ, also some nice specimens of healed-over galleries. The latter presented conclusive evidence that the attack had been made on healthy, growing trees. It seems that the trees succumb only after several years of successive attack by this insect. The extensive cutting of timber for fuel carried on here does not seem to answer the usual purpose of attracting the insects away from the living trees. Therefore, this is a problem of considerable interest, and, under more favorable conditions for study, should receive attention, in order to determine some method of preventing the ravages, which may prove to be even more extensive than at present. In the evening I called on Mr. W. H. Dolman, with a letter of introduction from Senator McBride, and that gentleman, from his experience and practical knowledge, was able to give me valuable information regarding the forest conditions in that section of the State.

Leaving St. Helen May 8, I arrived at Astoria, Oreg., the next morning, and made observations and collections in this most interesting locality.

May 9, I proceeded to Seaside, Oreg., where I learned of a serious trouble affecting the timber some 14 miles back on the Coast Range in the vicinity of Ahlers. I at once secured a guide and horses and pro-

ceeded some 7 miles that night. The next morning we followed a trail through the dense and magnificent forest here to Ahlers, where the timber, as far as could be seen in all directions, was dead. The trees had been dead eight or nine years; hence it was not possible to personally investigate the cause of the trouble. I was particularly fortunate, however, in obtaining from the postmaster, Mr. Herman Ahlers, a most interesting account of the beginning and ending of the trouble as observed by him at the time. It seems that the trees were defoliated, probably by a geometrid larva, in 1890–91, and that nearly all of the hemlock and Tideland spruce on an area lying between 450 and 1,200 feet above sea level in the southern half of Clatsop and the northern half of Tillamook counties died as a direct result of this defoliation.

Returning to Seaside May 11, I did some collecting there from scrub pine, Tideland spruce, and red fir, securing several species of insects new to the collection. At Hillsboro, Oreg., I called on Congressman Tongue, of the First district of Oregon, who heartily approved of the work in which I was engaged and expressed the hope that good results would follow.

May 12th proceeded to northern Washington to continue investigations in that region, stopping one day at Seattle, and arriving at Port Angeles May 15. Here two days were spent in active work, and many additional facts were determined and valuable material added to the collection. In addition to many of the same set of enemies of the common forest trees observed at other points visited, I found here a lepidopterous larva, as yet undetermined, which was quite common, feeding on the leaves of red fir.

Returning from Port Angeles, I stopped two days (May 17, 18) at Port Williams, Wash., where a special investigation was made to determine the cause of the death of a large number of white fir and red fir on a small military reserve there. It was found that the trees were being attacked by the same Scolytus as the one observed near McCloud, Cal., and also by a new Hylesinus. The red fir was infested with *Dendroctonus similis*, and it was quite evident that this species was the cause of their death. Some of the trees were felled for the purpose of making a thorough study of the insects inhabiting them. Some important facts were learned, and a large series of specimens of the insects and their work was collected.

Returning to Seattle on the 19th, I spent the next day with Professor Kincaid, entomologist at the State University, and several hours were employed in collecting on the extensive and partly forested university campus.

Leaving Seattle May 20, I proceeded to eastern Washington and northern Idaho, where nearly two weeks were spent in the vicinity of Spokane and Buckeye, Wash., and Sand Point and Kootenai, Idaho,

making investigations. Here I found quite different conditions prevailing from those observed in western Washington and Oregon in the prevalence of quite a different set of forest trees, notably the lodge-pole pine (*Pinus murrayana*), the mountain white pine (*Pinus monticola*), and the Western larch (*Larix occidentalis*), all of which yielded a large amount of new material and furnished new problems for study.

Among the more important observations made here was the common occurrence of the same Dendroctonus enemy of the yellow pine observed in northern California and southern and central Oregon. Many trees were found in the vicinity of Buckeye, Wash., which were dying or had died, evidently from the attack of this insect, since in every tree, of a large number examined, abundant examples of the insect and its work were found. I also found that a serious trouble had prevailed among the white pine in the vicinity of Kootenai, where a large amount of this most valuable timber had died within the past eight or ten years. Upon investigation I found quite conclusive evidence that the damage had been caused by another undescribed Dendroctonus allied to *D. frontalis*, but much larger than this or the one found killing the Western yellow pine.

Dendroctonus similis was found quite abundant in larch, excavating galleries and depositing eggs in living bark in recently felled trees. Its habits and the common occurrence of its work in standing dead trees indicated that it was one of the principal enemies of this kind of timber.

In addition to the above observations many others were made on the enemies of the pines, spruces, cedars, larches, birches, poplars, willows, etc., and a large series of valuable specimens was added to the collection.

After making quite a thorough investigation of the conditions found in this section of Washington and Idaho, I proceeded, on June 3, to Pullman, Wash., where I visited the Agricultural College and Experiment Station and called on the entomologist, Professor Piper.

June 4 Professor Piper took me into the forest at the base of Cedar Mountain, Idaho, where a few hours were spent in successful collection of insect enemies of the spruce, fir, pine, and other trees in this region. Many new observations were made here and much new material collected.

June 5 was spent with Professor Aldrich, entomologist of the Idaho University and Agricultural Experiment Station, who was naturally much interested in the object of my trip, since it was partly through his suggestion that this work was undertaken.

On June 6 I made another excursion into the forests of Cedar Mountain in company with the botanist of the University of Idaho, Professor Henderson, and three students from the botanical and entomo-

logical classes. Among the additional facts obtained on this excursion was the discovery that the Dendroctonus enemy of the yellow pine attacks trees defoliated by the pine butterfly (*Neophasia menapia*), and that it is quite intimately associated with the destruction of a large amount of timber only partly defoliated by the butterfly larva. Owing to the earliness of the season, no observations could be made on this insect which has been in previous years so enormously abundant and destructive in eastern Washington and in Idaho and Montana. Indeed, it was hardly necessary that I should do so, since the subject has received considerable attention at the hands of Professor Aldrich. Further information, however, on the relations of Scolytids to the subsequent death of trees only partly defoliated by it is a subject of considerable importance which I believe has not previously been taken into consideration.

Leaving Moscow on the 7th of June and going via Pendleton, Oreg., and Shoshone, Idaho, I arrived at Hailey, Idaho, June 9, where some successful collecting was made from red fir logs at a sawmill, and some valuable information was obtained from Messrs. Watt and Peacock regarding the forest conditions and timber interests of that section of Idaho. Learning of nothing else of especial importance requiring my attention, I started on my return journey to Washington, D. C., where I arrived on the morning of June 17, 1899.

The total distance traveled from Washington, D. C., and return by rail, boat, wagon, and on foot was about 9,000 miles; the time occupied, sixty-six days; the number of localities visited, twenty-six. The number of specimens collected is as follows:

Scolytidæ, mounted (counted)	1,074
Scolytidæ, in alcohol (counted)	2,003
Miscellaneous, principally Coleoptera, in alcohol (counted)	286
Miscellaneous, mounted and in alcohol (estimated)	350
Specimens of work of insects (counted)	650
Total	4,363
Separate notes in notebook	760

While the number of specimens is not as large as might have been secured by general collecting, the manner in which nearly all were collected from their host plants, and the large series of notes on their habits, makes them all the more valuable.

SUMMARY OF WORK AND RESULTS.

The above outline of the trip will indicate the character and amount of work done and the success attained in efforts to carry out instructions.

The distance traveled, the number of localities visited, and the limited time occupied in the trip from Washington and return left but

little time for actual work in the field. Realizing that this would be the case, I devoted my attention to the investigation of a few leading features which promised to yield the best results.

INFORMATION ON THE HABITS OF SCOLYTIDS MADE THE PRIME OBJECT.

Previous to this trip little had been published regarding the host plants and habits of the Scolytidæ of the Northwest, and scarcely any observations had been made on the relation of this destructive class of insects to the unhealthy conditions of the timber. I felt, therefore, that with my previous experience in the study of these insects in the forests of West Virginia, it was my first duty to obtain as much information as possible regarding the habits of those found in the localities visited, and I spared no pains or labor to accomplish this end. As a result of this effort specimens of some sixty species of Scolytids,[1] representing some twenty genera, were secured. This includes nearly all of the species heretofore known from northern California, Oregon, Washington, and Idaho. It also includes a large number heretofore unknown from this region, with representatives of two or three new genera. The host plants and some features of the habits and life history of every species were determined. A large series of biological material of both the undescribed and described species was also collected.

PRINCIPAL SCOLYTID ENEMIES OF THE FORESTS OF THE NORTHWEST.

The genus Dendroctonus.—This genus, which has been found to contain some of the most destructive enemies of the conifers of the East, was found to be represented in the Northwest by three described and two or three undescribed species. They were found here, as in the East, to be the principal enemies of pine, spruce, and larch; and from what was observed of their habits it is plain that under favorable conditions most, if not all, of them are capable of attacking and killing healthy timber.

One species which I have provisionally identified as *Dendroctonus brevicomis* Lec.[2] was found to be a most destructive enemy of the

[1] This is the number of the species determined by Mr. Schwarz and myself in a preliminary study of the entomological material. Subsequent identification of the mounted specimens may show that there are a few more or a few less species and genera.

[2] Heretofore this species had not been recognized since it was first described by LeConte. Dr. Dietz, in his notes on species of Dendroctonus of boreal America, states that he does not recognize any difference in typical specimens of *D. frontalis* Zimm. and *D. brevicomis*, Lec., and consequently concludes that they are identical. The examples I found are undoubtedly distinct from *D. frontalis*, although very closely allied to this species in specific characters and habits. It agrees so closely with Le Conte's description of *D. brevicomis*, however, that I think it must be recognized as such until a comparison with the type proves the contrary.

yellow pine (*Pinus ponderosa*) in northern California, southern and eastern Oregon, northeastern Washington, and western Idaho. A large amount of some of the finest timber in all of these localities had died within the past seven or eight years, evidently as a direct result of attacks by this bark beetle. It was also found to attack and prevent the recovery of trees injured by defoliating insects and other causes. Its habits and the character of its galleries appear to be identical with those of *Dendroctonus frontalis*, which is noted for its destruction of vast quantities of pine and spruce timber in West Virginia and adjoining States between 1890 and 1893. It is killing the Western yellow pine, just as *D. frontalis* commenced to kill the Eastern yellow pine (*Pinus echinata*) before it spread to all the other pines and spruce. Therefore, just as *D. frontalis* has proven to be the most destructive enemy of Eastern conifers, the Western representative of this species will doubtless prove to be, under similarly favorable conditions, equally as destructive to the Western forests in which the conifers predominate.

Among the most important features observed regarding the habits of this beetle was the fact that it is attracted to trees girdled by settlers and farmers in the process of clearing land, and that in the bark of such trees it breeds and multiplies in sufficient numbers to enable it to attack and kill the timber in adjoining healthy forests. Indeed, my observation leads me to conclude that a considerable number of girdled pine trees may easily form a nucleus for a destructive invasion by it.

A Dendroctonus allied to the one just mentioned, but evidently undescribed, was found to be a special and dangerous enemy of the sugar pine (*Pinus lambertiana*) and the mountain white pine (*Pinus monticola*), especially of the latter. It was frequently met with in the vicinity of Grants Pass, Oreg., in sugar pine, and was found abundant in the bark of dying and dead standing and felled white-pine trees in the vicinity of Sand Point and Kootenai, Idaho, where a large amount of timber had died, evidently as a result of its attack. This is the same beetle as the one sent to the Division of Entomology by Mr. Ayers from Columbia Falls, Mont., and subsequently sent to me, with other Dendroctonus material, for study. It is undoubtedly capable of attacking and killing great quantities of white and sugar pine, but may possibly be prevented from doing so in the future, in all regions where extensive timber cutting is carried on, by its being attracted to the stumps, logs, and tops of trees felled for lumber and fuel.

Another species, at present recognized as *Dendroctonus terebrans*, was commonly met with in the bark of living, dying, and dead standing trees and the stumps of recently felled *Pinus ponderosa*, *P. lambertiana*, *P. monticola*, *P. murrayana*, *P. contorta*, and *P. radiata*, in all of the localities where these species of pine grow. It was found to be quite a common enemy of the Monterey pine on the university campus at Berkeley, Cal., and I was informed by Professor Davy that

the unhealthy condition of this pine in its native home (Monterey County, Cal.) was probably due to the attack of this or of a closely allied bark beetle. The fact that it was not found in spruce, fir, or larch indicates that in the Northwest, as in the East, this large representative of the genus almost exclusively infests the pine. Its habit of attacking trees at the base is the same as in the East, as are also the social habits of the larvæ.

The information I was able to gather of the habits and different stages of the Western representatives of *D. terebrans*, of which nothing had been recorded, will aid greatly in arriving at definite conclusions regarding the identity of numerous doubtful forms collected on this trip, and those among the large series of material in the national collection.

Another Dendroctonus, referred to in my notes as "*Dendroctonus* sp., near *rufipennis*," proved upon comparison with identified specimens in my collection to be the same as examples labeled *D. similis*.[1] It appears that nothing has heretofore been recorded regarding the host trees or habits of this insect, yet I found it to be one of the commonest bark beetles of the region traversed, and a special enemy of the red fir (*Pseudotsuga taxifolia*). It was especially abundant wherever this tree was being cut for fuel or lumber. Partially developed broods were in the bark of trees felled the previous year, and some had emerged and were entering the bark of logs and stumps of recently felled ones, in the living bark of which they were excavating galleries and depositing eggs. On a small military reservation at Port Williams, Wash., I found it associated with the death of large numbers of red fir, and in eastern Washington and northern Idaho it was found to be quite as common an enemy of the Western larch (*Larix occidentalis*) as of the red fir. The fact that it was found so common in these two kinds of trees, and not in Picea or Abies, suggests that there is possibly a closer affinity between Pseudotsuga and Larix than has heretofore been recognized by botanists.

An undescribed Dendroctonus, near *D. rufipennis*, was found in the bark of Tideland spruce near Newport, Oreg. This beetle is represented in the national collection by a few large, black examples from Queen Charlotte Island, and in my collection by a large series recently sent to me for identification from the same island by the Reverend Keen. This is very likely a special enemy of the Tideland spruce, and, judging from the habits of other species of the genus, will doubtless prove at times quite injurious or destructive.

The genus Scolytus.—This genus, which is represented in the East by three common species which depredate on deciduous trees (viz, *Scolytus rugulosus* on fruit trees, *S. quadrispinosus* on hickory, and *S. muticus*

[1] This may, after all, prove to be *D. obesus* Mann., which LeConte believed to be synonymous with *D. rufipennis*. (Rhynchophora of North America, 1876, p. 385.)

on hackberry), is represented in the West by several species which infest conifers. The genus is of especial interest on account of the destructive powers of some of its representatives, which are capable of attacking and living in the bark of healthy trees. One or more unrecognized species allied to *S. præceps* were found to be primarily destructive to the wood of living white fir trees in all of the localities visited. The beetles attack the bark of healthy, vigorous trees and excavate their primary, or egg-galleries transversely through the inner bark and through the outer surface of the wood. When the attack is not sufficient to kill the trees, these wounds heal over, but in the meantime a decay often sets in at these injured places, which extends through the heart wood and for several feet above and below the wound, thus rendering the wood worthless for lumber, and often for fuel. That these trees were in a vigorous, growing condition when attacked was proven by the fact that in many instances a normal growth of wood and twigs had formed the year the attack was made, and when the injury was not sufficient to weaken the vitality of the tree a normal growth was made the next and succeeding years until the wounds were healed. At Port Williams, Wash., many trees were dying, all of which were infested with larvæ and pupæ of one or more of these Scolytus enemies, and it was quite evident that they had been the primary cause of the trouble.

Another species, at present recognized as *S. unispinosus*, was found to be a very common enemy of red fir along the coast, and of the red fir and Western larch in Idaho and eastern Washington. No evidence was found, however, that this species had caused the death of any of the trees.

The genus Tomicus.—This genus is represented in the collection by some ten species, four of which appear to be new. While I found some evidence to indicate that a species recognized as *Tomicus pini* was the primary cause of the death of numerous examples of the lodgepole pine in the vicinity of Spokane and of yellow pine near Moscow, Idaho, the other species appeared to occur only as secondary enemies or as allies of the more aggressive Dendroctonus.

Other Scolytids.—Among the other numerous species of Scolytids collected, none were recognized as specially destructive enemies of trees, except LeConte's *Hylesinus aspericollis*, which is not a Hylesinus, but appears to represent an undescribed genus, characterized by a seven-jointed antennal funicle. This I found infesting the living bark of white alder (*Alnus rhombifolia*), with evidence that it not only hastens the death of injured trees, but that it may be the primary cause of the death of healthy ones.

Examples of larvæ and pupæ, with a few dead adults, of an undescribed Hylesinus were found quite abundant in the bark of a felled hemlock at Newport, Oreg. This and the one found in alder are of

special interest from the fact that there appears to be no previous record of a Scolytid bark-beetle infesting either Alnus or Tsuga.

Another Scolytid, which does not seem to be referable to any known genus, was found in the thin bark of young dying sugar pine trees in the vicinity of Grants Pass, Oreg.; also in other pines and in the red fir.

The numerous other Scolytids represented in the collection made on this trip can not be mentioned in this preliminary report, but will form the subject of several pages of original matter in my final report on the results of this investigation.

DESTRUCTIVE BUPRESTID ENEMIES OF HEMLOCK, RED FIR, AND NOBLE FIR.

The evidence found in living, dying, and dead noble fir and hemlock in the Cascade Forest Reserve, at Berry, Oreg., and in hemlock and red fir along the Columbia River, in the vicinity of St. Helen, indicated that much loss of valuable timber had been due to the work of Buprestid larvæ in the living bark of these trees. The conditions at the time were not favorable for a study of this class of enemies or for a special investigation of the damage which seemed to be due to their attacks. It is, however, a subject of special importance, which will demand considerable attention in the future. Specimens of larvæ collected from the bark of living trees were provisionally identified by Mr. Schwarz as belonging to the genus Melonophila, probably *M. drummondi*, which is closely allied to *M. fulvoguttata*, a destructive enemy of the hemlock in West Virginia. An undetermined Cerambycid bark borer was found associated with the Buprestid larvæ in hemlock and red fir, but the evidence pointed to the Buprestid as having made the first attack.

FOREST TREE DEFOLIATORS.

While I did not have an opportunity, owing to the earliness of the season, to investigate the insects which are injurious and destructive to the foliage of forest trees, I found abundant evidence of this class of depredators, especially in the work of the pine butterfly on the yellow pine of eastern Washington and western Idaho, and the Geometrid of Clatsop County, Oreg., on Tideland spruce and hemlock.

The work of the pine butterfly has been previously recorded by Mr. Stretch, in Papillio (Vol. II, pp. 103–110), and subsequently copied in the Fifth Report of the United States Entomological Commission (pp. 762–767). The subject has also received special attention within recent years at the hands of Professor Aldrich, of the Idaho station; therefore the only observation made by the writer on this trip which it seems proper to mention in this connection is that relating to

Dendroctonus, Tomicus, and other Scolytids attacking the defoliated and partly defoliated trees. My observations led me to conclude that were it not for the secondary attack of the Scolytids many of these trees would have recovered from the injuries by the butterfly larvæ. Indeed, it seems to me that this association of bark beetles with defoliating caterpillars in causing the death of trees is an important feature to be taken into consideration in any study of troubles of this character.

The work of the supposed geometrid larva, found near Ahlers, Oreg., has not, I believe, been previously recorded, and, while I did not have an opportunity to see specimens of this insect, which has not attracted attention since the summer and fall of 1890, I obtained some valuable information from Mr. Ahlers regarding the character of the invasion, the insect, and the extent of its depredations.

Mr. Ahlers, postmaster at Ahlers, took a course in entomology at Wernigerode am Harz, Province of Saxony. Hence, his observations are of especial interest. Mr. Ahlers said:

> The worms commenced to attract a little attention here in 1889. A few moths were seen in the fall of the same year. In July, 1890, the worms appeared in great numbers, the first on the hemlock, feeding on the base of the leaves and cutting them off. When standing beneath the trees the droppings from the insects and the falling leaves sounded like rain. When all of the leaves were eaten from the trees the worms would let themselves down by means of webs, and, if they were not full grown, would feed on the leaves of all kinds of shrubs and trees, except the Douglas spruce and cedar. The worms were observed during July and August, and disappeared in the latter month, probably going into the ground to pupate. In October the moths began to come out. They were grayish white with dark markings on the wings. The wings spread about 1½ inches. The moths would appear on the wing about 3 o'clock in the afternoon in enormous swarms around the tops of the trees, resembling a white cloud. They continued to fly for about three weeks, at the end of which time the ground was covered with the dead insects, and the small streams were filled with them, in some places forming dams. The next year, 1891, they attacked the Sitka spruce and defoliated the trees, which died the following fall or winter. * * * When the worms were coming down from the trees the webs made the trees look as if they were covered with a grayish veil. The worms were about 1½ inches long, the sides grayish green, with darker gray zigzag markings on the back. When traveling they measured their way. This trouble extended over parts of Clatsop and Tillamook counties, killing all the hemlock and Sitka spruce in a belt between an elevation of about 450 and 1,200 feet above tide. The Douglas spruce and red cedar were not injured.

At the time of my visit much of the area covered by dead timber had been frequently burned over by forest fires, so that in some places nearly all of the dead timber had disappeared, but in other places, where the conditions had not been so favorable for the spread of the fire, the dead, barkless trunks of the trees were still standing, the tops broken and the branches fallen, the scene presenting at once a most impressive example of the destructive powers of an insect enemy of forests and of subsequent devastation by forest fires.

When it is considered that some of the spruce which grow here are 10 to 13 feet in diameter, 300 feet tall, and will yield more lumber

than many an acre of timber in the Eastern States, one can have some conception of the vast amount of timber which had been destroyed.

While the caterpillars which were primarily to blame for this destruction have not attracted attention within recent years, they will doubtless make their appearance again in destructive numbers and attack the remaining timber, which is becoming each year more accessible to lumbering operations, and hence rapidly increasing in value.

BENEFICIAL INSECTS AND DISEASES.

A large series of predaceous and parasitic insect enemies of the principal destructive species was collected, and many features regarding their occurrence, distribution, and habits noted. The predaceous enemies of Scolytids were quite common in nearly all of the localities visited, but the Chalcidid, Braconid, and Ichneumonid parasites of Scolytids and other bark and wood-infesting insects were rare as compared with the same class of insects in the East.

Numerous examples of diseases of both injurious and beneficial insects were found, and many insects had died from their effects. It was not possible, however, with the limited time at my disposal to determine the exact relation of these factors to the injuries caused by the principal enemies.

GENERAL OBSERVATIONS ON FOREST TREES AND FOREST CONDITIONS.

Forest trees recognized and studied.—Some 22 species of conifers and 14 of deciduous trees were recognized on this trip and their insect enemies studied, the following of which deserve special mention on account of their common occurrence and commercial importance.

COMMON NAMES.	BOTANICAL NAMES.
Redwood	*Sequoia sempervirens.*
Western yellow pine	*Pinus ponderosa.*
Sugar pine	*Pinus lambertiana.*
Silver pine (Western white pine)	*Pinus monticola.*
Red fir (Douglas spruce)	*Pseudotsuga taxifolia.*
Tideland spruce	*Picea sitchensis.*
Red cedar	*Thuja plicata.*
Western hemlock	*Tsuga heterophylla.*
Lowland fir	*Abies grandis.*
Noble fir ("larch")	*Abies nobilis.*
Western larch	*Larix occidentalis.*

Each of the timber trees named in this list was found to have one or more insect enemies. My observations on these trees and the relation of their enemies to the general condition of the timber may be briefly summarized as follows:

The redwood.—This appears to be an exceedingly hardy tree, and so far as I observed in the short time spent in the forests of this species in the vicinity of Guerneville, Cal., is in a healthy condition. It has

however, in *Phlœosinus cristatus* an enemy which, under especially favorable conditions, might prove quite destructive to standing timber. At present this insect is attracted to the bark of felled trees in which it breeds in great numbers. A Cerambycid bark borer, *Callidium janthinum*, was also found under the bark of a felled tree, and may be a common enemy.

The Western yellow pine.—This is widely distributed through northern California, Oregon, Washington, Idaho, and many other places wherever the soil and climatic conditions are favorable to its growth. Indeed, it is one of the commonest and most valuable timber trees of the region. From the evidence found it has probably a greater number of insect enemies than any of the other trees mentioned, and at present is suffering far more from their ravages. It has in *Dendroctonus brevicomis* a most pernicious enemy, which penetrates, and excavates winding galleries through, the living bark of the finest trees, thus speedily causing their death. Very many trees have died and are dying from this cause, and the dead ones are contributing to the spread of forest fires. Its next greatest enemy is the pine butterfly, which has, from time to time, defoliated and caused the death of much of the best yellow-pine timber in eastern Washington and in Idaho.

There are many secondary enemies of greater or lesser importance among the Scolytid genera Pityophthorus, Pityogenes, Xyloterus, Tomicus, Hylastes, and Hylurgops, which contribute to the death of trees primarily injured by defoliating and other insects, fire, and other causes. Numerous Buprestid and Cerambycid enemies of the wood and bark contribute to the unhealthy condition of the timber and the destruction of the wood. A lepidopterous larva infests the terminal twig of young trees near Moscow, Idaho, and one or more Curculionid beetles breed in the bark at the base of young and old trees.

The sugar pine.—While this, one of the most valuable timber trees of California and southern Oregon, is in a more healthy condition than the yellow pine, it has a dangerous enemy in an undescribed Dendroctonus as well as in the destructive enemy of the latter. It has also a host of other enemies which infest the twigs, bark, wood, and roots.

The silver, or western white pine.—This is a very common and most valuable tree in eastern Washington and in Idaho, and has a special enemy in the same undescribed Dendroctonus that infests the sugar pine. A vast amount of dead timber was found in groups and scattered through the forests in the vicinity of Kootenai and Sandpoint, Idaho, which showed good evidence, in the great abundance of galleries of this insect in the bark, that they had been killed by it. A Tomicus, closely allied to *confusus*, was also found to be a very common enemy, entering the living bark of recently felled trees; as was

also a Monohammus larva, which was found mining in, and destructive to, the wood of standing and felled trees.

The red fir.—This common and hardy timber tree of the Northwest, is of especial value both for its lumber and fuel product. While it is generally in a healthy condition, many dead and dying trees were found in all the sections visited, and in some places sufficient evidence was found to show that it had dangerous enemies in certain Buprestid and Cerambycid bark borers, which are capable of living in the healthy bark of growing trees. It has also a special enemy in *Dendroctonus similis*, which is everywhere common in the bark of dead and dying standing trees and in the dead and living bark of logs and stumps of felled ones. The evidence found in the dying trees on the military reservation at Port Williams indicates that this bark beetle may, under favorable conditions, be the primary cause of the death of the trees. *Scolytus unispinosus* is also a very common enemy, infesting the bark on the main stem of small trees, and on the branches of larger ones, which have been previously injured or felled. A lepidopterous larva was found feeding on the foliage near Port Angeles, and its common occurrence and habits of feeding indicate that it might easily become quite destructive to the foliage.

The Tideland spruce.—This is a magnificent tree, found in great forests along the coast in Oregon and Washington. It is attacked by several pernicious enemies, the principal of which is the undetermined Geometrid, mentioned on another page, which has destroyed immense quantities of timber and will doubtless be a menace to timber interests here in the future. The undescribed *Dendroctonus* found in the bark and trees of logs at Newport, Oreg., is a special enemy, as are also *Dryocœtes affaber*, *Hylurgops rugipennis*, *Xyloterus bivittatus*, and some other bark beetles which were found mining in the partly living bark or wood near Ahlers, Oreg.

Red cedar.—This is a common tree throughout Oregon and Washington, and is of especial value for shingles, telegraph poles, and lumber. Its principal enemies are one or more species of Phlœosinus and the Cerambycid, *Callidium janthinum*, which infests the living bark of recently felled trees and those injured by fire or other causes. The heartwood of living trees is also seriously injured by ants, which extend the damage started by Cerambycid heartwood borers, and a fungous disease. Numerous dead trees were observed in all sections of the forest, many of which had evidently died from injuries by one or more of these enemies.

The hemlock.—This is also a common hardy tree. It is attacked by the same destructive bark borers as those mentioned under red fir as well as by the Geometrid mentioned under Tideland spruce. In addition to these it has an undescribed Scolytid enemy which infests the bark. Many dead trees were found in the Cascade Reserve and both

dying and dead ones in the forests near St. Helen, all of which showed evidence of having been killed or injured by a Buprestid larva, while the great numbers of dead hemlock in Clatsop County, Oreg., were sufficient evidence of the destructive powers of the Geometrid.

The white or grand fir.—This is a very common tree, which would be of special value for the manufacture of pulp but for serious injuries by one or more species of Scolytus and Hylesinus, which infest the living trees, causing a decayed condition of the wood of some and the death of many others, so that the fir is often in an unhealthy condition and the dead and decaying trees contribute to destructive forest fires. It also has a number of other Scolytid, Buprestid, and Cerambycid enemies which infest the wood and bark. The same caterpillar that was found attacking the foliage of the red fir was also found feeding on the leaves of this fir.

The noble fir.—This is, as its name indicates, a most noble tree, found in its perfection at moderate altitudes. It has a serious enemy in the Buprestid, similar to, if not identical with, that which attacks the red fir and hemlock. While I did not have an opportunity, owing to deep snow, to make extended observations regarding the condition of this timber, it would appear from what was seen in the Cascade Reserve that many of the finest trees have died and that an unhealthy condition prevails.

The Western larch.—This larch, unlike its Eastern representative, grows chiefly in dry sandy or gravelly soils and attains a diameter of 3 or 4 feet. It appears to me to be a very hardy tree, often retaining its vitality for months after it is felled. It has a common enemy in *Dendroctonus similis*, which, as previously stated, is capable of doing considerable harm to this tree and the red fir. Many dead trees were found showing evidence of having been killed by it, and the beetles were common, entering the living bark of recently felled trees in the vicinity of Kootenai, Idaho. A Buprestid bark borer, probably *Melanophila*, was found in all stages of the bark in felled trees, and *Scolytus unispinosus* was common in the inner bark of the tops and branches of trees felled in the summer of 1898. The number of dead trees observed and the common occurrence of dead branches on living ones indicated that considerable damage had been done by its insect enemies.

GENERAL OBSERVATIONS ON SOME FOREST PROBLEMS OF THE NORTHWEST.

My interest in forest subjects in general and previous studies of the forest conditions in West Virginia led me to make some general observations on the forest problems of the Northwest which are in any way related to insect depredations, such as the influence of farm-

ing and lumbering methods, mining operations, forest fires, and diseases of trees.

Influence of farming methods.—I found that, in addition to the girdled timber contributing to the multiplication of dangerous insect enemies of forests, the clearings made in the midst of primitive forests by the settlers and farmers expose the trees on the borders of such clearings to abnormal influences, which weaken the vitality of the matured timber. The destructive insects and their allies, breeding in the girdled trees, emerge and attack these weakened ones, and with this additional material, and most favorable conditions for their multiplication and spread into the healthy forest, a trouble is often started which results in the destruction of vast quantities of timber.

Influence of lumbering methods.—The abundance of timber in this great forested area and the cost of transporting the products to market leads in most cases to wasteful lumbering methods, only the best timber suitable for special purposes being taken. The remainder, which in a short time would be just as valuable for other purposes, is left with scarred trunks, broken tops and branches, and deprived of the protective environments under which it had developed. The ground is strewn with tops, branches, and trunks of the felled timber, which, with the injured standing trees, furnish the most attractive breeding places for all bark and wood infesting insects. If the cutting is continued from year to year in the same locality the insects, upon emerging from the débris of the old cuttings, migrate to that of the new, and do not invade the healthy or undisturbed forests. If, on the other hand, cutting is discontinued and the débris is not destroyed by fire, there is great danger of the insects, upon emerging, attacking the healthy timber in the surrounding forests and continuing their ravages there.

The relation of forest fires to depredations by insects.—This is a subject to which little attention has heretofore been given. My observations in the fire-swept areas in the Northwest has, in addition to previous observations in West Virginia, convinced me that this is a problem of considerable importance. Trees dying from injury by fires furnish favorable breeding places for vast numbers of destructive and other bark and wood infesting insects. Those slightly injured and weakened in vitality are prevented from recovery by the attack of bark beetles, which are ever ready to take advantage of any opportunity to overcome the resisting forces of their favorite host plants. Thus the most favorable conditions are offered for the multiplication of insect depredators, which, through their augmented power in increased numbers, are capable of extending their ravages into the healthy forests. Fire wounds at the bases of living trees also lead to serious trouble and losses of the most valuable timber. These wounds give entrance to Cerambycid and Buprestid heartwood borers, black

ants, and wood-decaying fungi, all of which extend from year to year their obscure yet destructive work. Nor does the trouble end here. The dead trees and decaying wood of the living ones, as indicated on previous pages, offer most favorable conditions for the starting and spread of forest fires. It is therefore plain that in considering methods of preventing depredations by insects those relating to the prevention of forest fires are, under certain conditions, of special importance.

In the nonreserved forests, where extensive timber operations are carried on, the prevention of forest fires as a means of controlling insect depredations is far less important than in the reserves. In fact the débris in cut-over areas serves as attractive traps for the insects, where they may be effectually destroyed, or their migration to healthy timber prevented, by the almost inevitable conflagrations which follow these cuttings. Therefore under such conditions it is not so much the problem of prevention of fires as that of their control which should receive attention, since if this débris can be burned at a time when the conditions are least favorable for the fire to spread into the standing timber the desired good, in the destruction of insects, would be attained and the evil effects of the fires averted. On the other hand, every possible effort should be made to prevent outbreaks of fires in virgin and reserved forested areas, not only to prevent the vast destruction by fire alone, but as a precaution against destructive ravages by insects.

Relation of insect enemies of trees to forest fires.—This is a subject on which nothing appears to have been published, yet it requires only a little observation in the Western forest to make it clear that the trees which have been killed by insects furnish, in their fallen branches, standing and fallen partly decayed trunks, and dry bark, a most favorable condition for the starting, rapid spread, and perpetuation of forest fires.

The relation of diseases of trees to insect enemies of forests.—It is well known that forest trees weakened by disease contribute to the multiplication of their insect enemies. It is also known that insects will attack healthy trees, and that diseases of the bark and wood follow as a result of such injuries. Therefore, in the investigations of unhealthy conditions of forests it is often exceedingly difficult, without some previous knowledge of the habits of the diseases and insects found associated with them, to decide which is to blame for the primary injury. Our present knowledge of the subject, however, indicates that as a rule unhealthy forest trees, like unhealthy animals, present characteristic symptoms, which indicate quite clearly the primary cause of the trouble. The evidence I have been able to gather in the forests of the East and Northwest makes it plain to me that, of the two causes, while many small trees are killed by root diseases, the unhealthy condition of the larger trees is more often due to primary attacks by insects. Indeed, it appears that insects contribute more to

the spread of fungous diseases of the bark and wood of the main trunk than do such diseases to the spread and ravages of insects.

The most striking example of insects contributing to the spread of fungous diseases was observed in the white fir throughout the region traversed; the heartwood of which is commonly rendered worthless by decay as the result of wounds in the living bark made by Scolytus bark beetles.

Interrelations of forest fires, insects, and fungous diseases.—It will be seen from the foregoing references to the relation of forest fires to insect ravages, insects to forest fires, diseases of trees to insects, and insects to fungous diseases, that there is a close interrelation, and, to a certain extent, interdependence of all of these factors in the destruction of valuable forest products. While I had made some observations along this line in the forests of West Virginia, I had little conception of the magnitude and importance of the problem previous to my trip through the forests of the Northwest, where quite conclusive evidence was found that had it not been for previous depredations by insects and consequent rapid decay of the standing and felled timber, far less destruction by forest fires, or need for trouble and expense in efforts toward the prevention and control of this prevalent evil, would have occurred. It was also evident from the conditions observed in some sections that practical means of greatly mitigating the destructive effects of these separate and combined causes of prevailing troubles could be had through a better knowledge of some of the leading features of this problem.

CONSIDERATION OF PREVENTIVES AND REMEDIES.

The object of the trip was to study insect enemies of forests and causes of prevalent unhealthy conditions, rather than the subject of preventives and remedies. Indeed, much additional and detailed investigation relative to the life histories and habits of the more destructive enemies, and of the conditions which affect them is necessary in order to obtain evidence on which to base reliable conclusions.

The fact that the Western destructive pine-bark beetle is attracted to girdled trees, suggested girdled and felled trap trees as a practical method of preventing and checking destructive outbreaks of this and other insects with similar habits, especially in forest reserves, and I think some experiments should be conducted in order to determine whether or not this would prove effectual.

The discontinuance, so far as possible, of the common practice of settlers and farmers girdling pine and spruce trees and leaving them standing in the clearing from year to year was suggested by the conditions observed as a most important precaution against the multiplication and destructive outbreaks of certain dangerous enemies of conifers. On the other hand if such girdled conifers could be felled

and the bark removed before the broods of bark-beetles emerge, vast numbers of these pests would be effectually destroyed.

The prevention and intelligent control of forest fires is also believed, as previously stated, to be a most important precaution against the extension of insect depredations, as is also the prevention of insect ravages, and the proper management of timber killed by them, a necessary precaution against forest fires.

The introduction of natural enemies of destructive insects as a means of controlling them might prove effectual under certain favorable conditions, but before this or any other method is recommended for the prevention and control of forest pests, each separate trouble, and the attendant physical and other conditions prevailing in the region or forest in which it prevails, should be thoroughly studied.

SUMMARY AND RECOMMENDATIONS.

Before concluding this preliminary report it seems proper to call attention to some of the insects and subjects relating to their destructive ravages which the results of my investigation suggest as the most important for investigation. The insects mentioned in the following list were found to be of special economic importance on account of their destructive habits, and therefore demand primary consideration:

Dendroctonus brevicomis Lec., a widely distributed and common barkbeetle, destructive to the Western yellow pine and the sugar pine; observed in California, Washington, Oregon, and Idaho.

Dendroctonus n. sp., a common and destructive enemy of the white pine and the sugar pine; observed in Oregon and Washington, and reported from Montana and South Dakota.

Dendroctonus similis Lec., a very common and widely distributed enemy of the red fir and Western larch; observed in California, Oregon, and Idaho.

Scolytus præceps Lec. and closely allied species, one or more of which are very common, widely distributed, and destructive enemies of the fir; observed in California, Oregon, and Idaho.

Geometrid larvæ, destructive to the foliage and causing the death of vast quantities of Tideland spruce and hemlock in Clatsop and Tillamook counties, Oreg.; the result of its work observed.

Melanophila drummondi Kirby, or a closely allied species, a common and destructive enemy of the red fir, hemlock, and noble fir; larvæ and work observed in Oregon, Washington, and Idaho.

Neophasia menapia Feld., the pine butterfly, a common and destructive enemy of the Western yellow pine in Idaho and eastern Washington; its destructive work observed.

The first five insects named in this list are probably the five worst insect enemies of the Western forest. The evidence found indicates that they have caused the death of many million dollars' worth of the

finest timber and that they are capable of causing greater losses in the future. Nothing whatever seems to have been published regarding the habits of any of them, and little or nothing was known of their economic importance previous to the investigation here reported.

The interrelation of forest fires, insect enemies, diseases of trees, and human agencies in the destruction of forests, is a problem of especial importance, the investigation of which will, no doubt, yield most valuable results.

I would also suggest the importance of conducting experiments with girdled and felled trap trees in some of the forest reserves threatened by bark beetles, to determine their value in preventing and controlling the ravages of destructive bark-infesting insects. Experiments in partially burning dead timber and the débris left by timber cutters, at a time of year when the conditions are least favorable for its spread, is also a line of work which seems to be promising in results.

A study of certain prevailing physical conditions in the Northwest and their relation to distribution, common or rare occurrences, and destructive habits of the principal insect enemies of the forest, will also surely lead to results of special interest and value.

In addition to results of economic importance, the investigation of the subjects mentioned, involving as they do technical studies of the insects and of broad problems relating to their life, should lead to valuable contributions to science.

In conclusion, may I suggest that the increasing public interest in forest protection, the vast forested domain included in reserves and national parks, the aggregate public and private wealth in undeveloped forest resources, and the extensive destruction of the best timber each year by insects and related evils seem to warrant giving this heretofore neglected feature of the forest problems of this country especial attention. It is a line of scientific research which, in consideration of its relation to their work and interests can not fail to receive the hearty support and cooperation of other divisions of the public service—such as the Division of Forestry, the General Land Office, the State experiment stations and forestry schools.

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